PROGRAM IMPROVEMENT EFFORTS FOR THE ATE PROGRAM

APPROACHES AND RESULTS IN IMPROVING TECHNICAL EDUCATION PROGRAMS BY ATE CENTERS AND PROJECTS

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Executive Summary

Program Improvement Efforts for the ATE Program

Approaches and Results in Improving Technical Education Programs by ATE Centers and Projects

The NSF ATE program is the Congressionally mandated governmental focal point for creating a U.S. world-class technical workforce through education. Based on the Congressional charge, ATE established developing model instructional programs in advanced technology fields as a major program objective. Although secondary schools and four-year colleges have a role in accomplishing this objective, two-year colleges are the major focus in increasing the pool of skilled technicians.

The term *program improvement* is viewed by the Western Michigan University's (WMU) evaluation project at The Evaluation Center as a process of comprehensive curriculum development and associated improvements that results in the production of cutting-edge skilled technicians. This process is a combination of efforts that address changes to the multiple aspects of a technical degree or other technical award program. These include identifying and integrating industry standards and workplace competencies; creating instructional module/course changes; adding rigorous STEM content; implementing work-based education components; facilitating equipment modernization; integrating appropriate pedagogical approaches; increasing minority participation; providing faculty development; etc. Activities that are associated with direct course/instructional improvement are referred to by WMU's evaluation project as *Materials Development* and, when pursued as part of an integrated effort to develop new or upgrade existing technical programs, is a major component in program improvement. The major difference between program improvement and materials development is that ATE *projects* involved in program improvement are engaged in materials development as well as other comprehensive activities such as standards development, faculty professional development, and recruitment/retention activities; and the program results in the award of an appropriate degree or certificate of accomplishment to program completers.

To evaluate ATE's effectiveness in the process and results of *program improvement*, a construct was developed. The elements of the construct are listed below:

1. A curriculum development and implementation process
2. Normally led by a community college
3. Revises or develops an educational program
4. Consists of an organized sequence of classes, laboratories, and work-based educational experiences
5. Prepares diverse student populations with the knowledge and skills required for employment in a specific advanced technological field
6. Is available to students over a significant period of time

7. Emphasizes STEM standards, communication skills, critical thinking, advanced technology courses, workplace competencies, equipment use, teamwork, and perseverance
8. Leads students to an appropriate degree, certification, or occupational competency point
9. Provides industry with an increased pool of competent, advanced technicians
10. Can be located at secondary schools, two-year colleges, or four-year colleges or universities
11. Structured to obtain maximum articulation of educational experiences

The above construct is lengthy and, in some ways, a complex melding of components and outcomes. However, a simpler construct would not provide an adequate framework for the exploration of best practices and ATE-funded *projects*'' performance in improving their curriculum programs. Using data from surveys, field visit reports, and program documents, a point-by-point analysis of ATE *project* performance is provided in the paper. A summary of this analysis follows:

- Basically, the program improvement *projects* are meeting the identified developmental aspects of the ATE program.
- Overall, the *projects* involved in program improvement are oriented to improving STEM in their programs, and in the case of associate degree programs, in feeder secondary programs.
- The improved programs reflect use of general mathematics, science, and communications across the technical curriculum component.
- Use of standards to determine student competencies are universal, and when the work-based standards are not available, programs work with business and industry to identify them.
- The use of work-based education as part of the curriculum is also standard, but is not always a requirement.
- Projects integrate development of "soft skills" such as teamwork and critical thinking into their programs.
- The improved programs provide certification or award a degree as appropriate.
- At the associate level, there are usually multiple educational tracks to meet the need of students with a variety of backgrounds and goals.
- Articulation of the transfer of prior learning experiences between community colleges and their four-year counterparts are the norm.
- There is very limited articulation involving granting advanced standing of students between secondary and community college programs.

The conclusion reached is that the issue is not the development of model instructional programs, but the lack of data on their performance. Data are lacking on the following key aspects of program improvement results:

- The absence of formalized pilot and field-testing involving business and industry prevents verification of the programs' effectiveness and limits revision to meet the original or new program/course objectives.

- Limited documentation of courses likewise limits dissemination and adaptation by other programs.
- Approaches to reaching a diverse student population via appropriate pedagogy is not documented in curriculum materials, and the effective use of these approaches is unknown.
- Data on performance by program completers (either on the job or in continuing education) is not routinely gathered or analyzed, nor are plans to do so evident.
- Only limited data are available on the number of completers reaching industry.

The deficiencies outlined above will have to be addressed before ATE's program improvement effort can be fully evaluated. To assist in addressing these deficiencies, a series of recommendations are provided for ATE program managers:

1. Continue the increased emphasis on disseminating products that are developed by ATE *projects* and develop a protocol for measuring the impact of these efforts, since materials development is integral to program improvement
2. Place greater emphasis on pilot and field-testing of the materials developed for the programs by the *projects* and encourage the involvement of business and industry in these activities
3. Define minimum standards for documentation of materials, and require *projects* to meet or exceed these standards
4. Encourage *projects* to identify, document, and use advanced pedagogical approaches to meet the learning needs of a diverse population
5. Fund *projects* that develop replicable strategies for increasing articulation between secondary schools and associate degree colleges, which provide secondary students with advanced college standing
6. Define the protocol for routinely gathering program improvement outcomes data (including those in underrepresented populations and resulting from product dissemination), and analyze these data in relation to the U.S.'s requirements for skilled technicians
7. Develop and fund longitudinal evaluations of the performance of those who complete improved programs
8. Continue to fund external evaluation of the ATE program, including on-site visits, to determine an independent measure of the impact of efforts to increase skilled technicians. As part of the evaluation effort, data-reporting methodology should be refined and standardized to increase the usefulness of these data.

A recommendation for program improvement *projects* and a suggested approach to evaluation of these *projects* are also included in this paper.

Table of Contents

Program Improvement Efforts for the ATE Program

Approaches and Results in Improving Technical Education Programs by ATE Centers and Projects

The Intended Audiences for This Paper

This paper addresses the process and results of technical education program improvement efforts as part of the National Science Foundation's (NSF) Advanced Technological Education (ATE) program[3] and is primarily intended for the use of ATE staff. It contains information and recommendations that may also benefit funded ATE *projects*[4]. For these *projects*, a schema for evaluating program improvement strategies and outcomes is also included. Additionally, organizations or individuals seeking ATE funding that involves strengthening technical education programs may find the paper useful in developing their proposals. Educators also may determine how their efforts to increase science, technology, engineering, and mathematics (STEM) topics in technical programs are being applied by ATE funded *projects*. Finally, members of the Congressional staff involved with ATE funding may gain some insight from the paper in terms of the current state of the ATE effort to provide more skilled technicians for U.S.'s workforce.

Origins of ATE Program Improvement Efforts

The NSF's ATE program responds to the *Scientific and Advanced – Technology Act of 1992 (PL 102-476).* The Act's purpose is to improve the competitiveness of the U.S. in international trade by increasing productivity through increasing the pool of skilled technicians. To accomplish this, NSF was directed to establish a national program to improve the education for technicians in advanced technology fields. Although secondary schools and four-year colleges have a role in accomplishing this objective, two-year colleges are the major focus for increasing the pool of skilled technicians. NSF, to carry out the Congressional mandate, initiated the ATE program.[5] In turn, ATE established the development of model instructional programs in advanced technology fields as a major objective.[6]

For the purpose of this paper, many ATE-funded activities associated with developing model instructional programs are identified as *program improvement*. The WMU evaluation project[7] views this as a process of comprehensive curriculum development and associated

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[3] Please see the attached overview document (*The ATE Program: Issues for Consideration)* accompanying this paper for a detailed description of this program and its evaluation.
[4] This paper will follow the WMU evaluation project's convention that *project* in italics is used to denote ATE funded projects and centers.
[5] *Status Report 1: The Nature of the ATE Program*, p. 1, Kalamazoo, Michigan: The Evaluation Center, Western Michigan University, May 2000.
[6] Ibid., p. 3, Table 3.
[7] The Western Michigan University evaluation project at The Evaluation Center, Kalamazoo, Michigan, has been funded by NSF to conduct an independent evaluation of ATE projects.

improvements that results in the production of credentialed, cutting-edge, skilled technicians. Comprehensive curriculum development and associated improvement are efforts that address changes to the multiple aspects of a technical degree or other technical award program. These include identifying and integrating industry standards and workplace competencies; creating instructional module/course changes; adding rigorous STEM content; implementing work-based education components; facilitating equipment modernization; integrating appropriate pedagogical approaches; increasing minority participation; providing faculty development; etc. Activities listed above that are directly associated with course/instructional development and improvement is referred to by WMU evaluation project as *Materials Development*. Materials development can also be a stand-alone activity not directly tied to a specific academic program. However, when pursued as part of an integrated effort to develop new or upgrade existing technical programs, materials development is a major component in *program improvement*. The major difference between program improvement and materials development is that ATE *projects* involved in program improvement are engaged in materials development as well as other comprehensive activities such as standards development, faculty professional development, and recruitment/retention activities; and the program results in the award of an appropriate degree or certificate of accomplishment to program completers.

Program Improvement Defined

For the purpose of this paper, a hypothetical construct for *program improvement* is needed to provide a framework for discussing and evaluating ATE's efforts to create model instructional programs. The approach selected is to define the elements that are included in program improvement efforts. The components of the definition to be used in the paper are presented below.

Elements of program improvement. The term *program* is perhaps the key to developing a workable construct. In terms of the ATE effort, *program* has many meanings depending on the context in which it is used. For the purpose of this paper, a program will (1) be educational in nature; (2) generally be led by a community college[8]; (3) focus on preparing students in advanced technological fields; (4) be an organized sequence of classes; (5) consist of a comprehensive curriculum spanning an extended period of time; and (6) result in increased numbers of credentialed, skilled technicians in the workforce.[9]

The construct "improvement" also is multifaceted and includes the following elements: (1) implements the national science, mathematics, technology, and industry standards in education; (2) creates effective courses in science and technologies based on strong student mathematics and science backgrounds; (3) recognizes current and projected occupational requirements and gives prospective technicians insight into real-world work environments; (4) serves first-time and returning students and workers seeking new career opportunities or skills; (5) provides students experience with appropriate equipment; (6) integrates instructional approaches that encourages student writing, oral presentations, group learning,

[8] As a matter of convenience, the term *community college* will be used in this paper when referring to associate-degree-granting colleges.
[9] *Advanced Technological Education (ATE), Program Solicitation.* 2000, p. 5-7.

and completing long term projects; and (7) engages students in the practice and thought processes of formulating problems and questions, designing appropriate models, troubleshooting, and using technological tools[10].

ATE also provides some additional expectations for comprehensive curriculum improvement efforts that pertain to the concept of *program improvement* outlined above. The first of these is *articulation*. [11] The expectation is that improved curriculum will be articulated between secondary schools, two-year colleges, and four-year colleges and universities. The second is *achievement of workforce diversity* by recruiting, retaining, [educating] and placing students from groups underrepresented in STEM fields.[12] These expectations impact program improvement efforts, particularly in areas of content (ensuring acceptability at higher levels), and the use of a variety of pedagogical approaches appropriate to diverse learning styles. To meet both of these expectations, the availability of a series of developmental or bridging courses to attain the readiness needed to master the curriculum can be required.[13]

One other source that delineates program improvement is the WMU evaluation project. This project defines program improvement as *"efforts to create effective workforce technician education programs at the (a) secondary school, (b) associate degree, and (c) baccalaureate degree levels. 'Program improvement' refers to multiple, related courses, and/or field experiences for students at the designated education level that facilitates attaining or leads to a defined outcome such as a degree, certification, or occupational completion point."*[14]

The WMU evaluation project's definition adds three parameters to the construct of *program improvement* that will be used in this paper. Based on this definition, there are three distinct academic levels for improvement—secondary schools, associate degree, and baccalaureate degree. Additionally, the definition stipulates the program's end result is a defined outcome, that is, leads to an award (such as an academic degree) or attainment of a recognized occupational level (The author assumes that the definition implies that the attainment of an occupational level is associated with a formally recognized standard). WMU's definition also includes the components of an organized sequence of classes that form a comprehensive curriculum spanning an extended period of time.

The program improvement construct. Using the information provided above, the construct for program improvement used in this paper is

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[10] *Advanced Technological Education (ATE), Program Solicitation.* 1997, p. 4-5 & 2000, p. 7.

[11] Articulation as used here is the recognition of educational experience and/or the transfer of "credit" from a lower level to a higher level that results in advanced standing at the higher level.

[12] *Advanced Technological Education (ATE), Program Solicitation.* 2000, p. 11-12.

[13] Developmental education efforts are a basic commodity in two-year colleges, which generally have no or limited requirements for enrollment. As a result, this "open door" philosophy requires these colleges to provide remediation of underprepared entering students in order to provide the academic readiness needed for success in the college's programs. This paper will simply note the need to prepare students for success in ATE improved programs, since a discussion of development programs is beyond the scope of the topic of *program improvement.*

[14] ATE Site Visit Report Outline, *ATE Drivers,* The Evaluation Center, Western Michigan University. Kalamazoo, Michigan, Distributed September 2000.

ATE sponsored program improvement is a curriculum[15] *development and implementation process, normally led by a community college, which revises or develops an educational program that prepares diverse student populations with the knowledge and skills required for employment in a specific advanced-technological field. The program is an organized sequence of classes, laboratories, and work-based educational experiences available to students over a significant period of time and emphasizes STEM standards, communication skills, critical thinking, advanced technology courses, workplace competencies, equipment use, teamwork and perseverance. The improved program leads students to an appropriate degree, certification, or occupational competency point, and provides industry with an increased pool of competent skilled-technicians. Programs can be at secondary schools, two-year colleges, or four-year colleges or universities and should be structured to obtain maximum articulation of educational experiences.*

Elements used to judge program improvement. The above construct is lengthy and, in some ways, a complex melding of components and outcomes. However, a simpler definition would not provide an adequate framework for this paper's exploration of ATE centers'/projects'[16] performance in improving their curriculum programs. When discussing the data about *projects* with a stated objective of producing skilled technicians, the following definitional elements from the *program improvement definition* will be judged. The *project*:

1. Revises or develops a technical educational program
2. Reflects an integrated curriculum development and implementation process
3. Is an organized sequence of classes, laboratories, and work-based educational experiences
4. Emphasizes STEM standards, communication skills, critical thinking, advanced technology courses, workplace competencies, equipment use, teamwork, and perseverance
5. Is conducted and available to students over a significant period of time
6. Prepares diverse student populations with the knowledge and skills required for employment in a specific advanced technological field
7. Leads students to an appropriate degree, certification, or occupational competency point
8. Provides industry with an increased pool of competent skilled technicians
9. Is structured to obtain maximum articulation of educational experiences

The Program Development Process

Prior to reviewing these performance data, a limited overview of how technical programs are developed is of value in creating a perspective of what ATE-funded *projects* would be expected to do during their efforts to improve a program. Although it might seem that the process would be different, depending on whether the program was being "revised" or

[15] *Curriculum* as used hereafter in this paper is synonymous with the term "program" in *program improvement*. As used, both curriculum and program are a sequential set of learning experiences, which results in achieving a defined set of specific occupational competencies and, as appropriate, certification or award of an academic degree.
[16] Centers are expressly identified in ATE funding and are more comprehensive and funded for a longer duration than projects.

"created", in actuality the difference is more in degree than activities. Both program revision and creation start with a need. The specifics of how the need is determined and quantified is relatively unimportant as long as it is factually sound. It is probably safe to assume that a proposal for program improvement (as described above) submitted to ATE for funding consideration clearly establishes the need in a context of providing an increase of skilled technicians for the U.S.'s workforce. If not, it could reasonably be expected that the proposal would not be funded. Therefore, as a starting point, this paper will be based on the assumption that funded program improvement *projects* meet a recognizable manpower development need.

Differing levels of program improvement. As defined, program improvement can occur at one or more educational levels—secondary school, two-year college, or four-year college and university levels. Based on the concept that community colleges will provide leadership in ATE-funded *projects*, the most common effort would be expected at the two-year college level.

The two-year college generally has a variety of "levels of occupational attainment." These consist of programs ranging from approximately one academic year with no or limited related "general education courses"[17] to the associate degree consisting of 60 or more semester hours of study, including an array of general and technical education courses[18]. In some colleges, there are intermediate levels that include a minimum of general education and a more limited number of technical offerings than in the degree program. A variation on the theme is noncredit education programs designed for workers upgrading their skill and knowledge levels and consisting of sequential technical offerings. In terms of program offerings, the community college, to serve its multifaceted enrollments, normally provides multiple options for potentially diverse populations of technical students. Therefore, it is important to clearly identify the audience when reviewing program improvement efforts at the two-year college level. An example would be the "all technical content" sequence for "reverse transfer students"[19] and the associate degree sequence for students with no or little postsecondary education experience. Both of these would be considered technical programs in context of the ATE program and this paper.

The matrix of occupational attainment levels is less complex at the secondary school and the four-year level. Secondary schools, with the exception of vocational programs, tend to have a core of mandated curriculum offerings that are general knowledge/skill building versus intense preparation in a specific technical field. However, the educational reform movement sweeping the U.S. along with the federal school-to-work initiative have increased the focus of K-12 education toward preparing students for future employment, including increasing technological awareness and use. These efforts, however, normally do not provide concentrated, discipline-oriented instruction in advanced technical fields. The vocational

[17] In this paper, related academic offerings such as writing, mathematics, science, and speech will be referred to as general education. Appropriate credentialed faculty teach these offerings.

[18] The term *technical education* refers to offerings of focused technical content and are generally taught by professionals in the technical content area.

[19] *Reverse transfer* is a term used to identify students with a four-year degree returning to a two-year college to gain technical knowledge and skills to increase their employability by business and industry.

education component of secondary schools does aim to provide high school graduates with employability skills without further education. These vocational courses, considering they represent the 11th and 12th grade levels of secondary education, may not contain the intense emphasis on STEM-based technology desired by ATE programs. ATE program guidance appears to recognize this limitation and speaks to collaboration with secondary schools in the design of curricula and instructional materials that provide a foundation for technical education.[20] There are articulated vocational programs at community colleges that provide advance standing for students in matching disciplines.

At senior institutions, the programs are oriented toward the baccalaureate degree or higher. At the baccalaureate level, numerous disciplines are advanced technology oriented and contain an emphasis on STEM-driven courses. ATE program solicitation guidelines take special note of the direct relationship of these baccalaureate degrees to associate degree technical disciplines. The solicitation guidelines allow support of "partnerships in which two-year colleges work with four-year colleges and universities to develop, implement, and evaluate model programs that enable students to make successful transition from a STEM associate's degree program to a related bachelors degree program."[21]

The matrix of educational levels that meet the program improvement definition used in this paper consists of a variety of community college offerings from noncredit professional development programs to multiple-year associate degree programs. At the four-year level, the bachelor's degree is the primary award. The achievement of a defined occupational level in secondary schools is generally restricted to vocational tracks during the 11-12th grade years.

External requirements and program improvement. In this section, the general parameters that are usually imposed on new curriculum/program development are discussed. Since each institution, state, and region has its own rules, there will be no attempt to provide specific requirements, but a general pattern of reviews and approvals will be presented. However, these procedures are universal for state-funded institutions and vary only in degree of complexity and control of detail.

Several levels of governance/management impact new program improvement. A high school, two-or four-year college, or a university cannot simply say "let's develop program x" and do it. The process for approval of a college's degree program, particularly at publicly supported institutions, is lengthy. The first level of approvals is the institution itself. There are administrative processes, faculty review, and usually institutional governance approval for new programs.

For two-and four-year degree programs, there is a state level process for approval of new programs (and sometimes even for new courses). The rigor of the review varies greatly. In the most centralized systems, a "state approved standardized curriculum" is required. In others, the approval process is a review of a more limited proposal. The author's experience

[20] *ATE Program Guidance*, 1996, p. 12.
[21] *ATE Program Solicitation*, 2000, p. 16.

indicates a trend toward more control by states as public funding dollars have become less available.

The processes highlighted above pertain mainly to new degree offerings (and in some cases formal certificate programs below the associate degree level). Time for approval of new programs can range from one to two years. Revising existing programs is usually easier to accomplish from a review and approval process standpoint. However, as newer technologies emerge, new programs will require development. A method of "fast tracking" approval of new technical programs needed by business/industry could be beneficial in meeting needs for newer disciplines such as those in biotechnology.

Additionally, there are usually state requirements for lay business/industry advisory committees at the associate level to continuously work with and advise technical program faculty. These committees may be active in reviewing and recommending modification to curriculum content.

Regional accreditation agencies also impose requirements on formal degree programs. These requirements are generally in the mix of general education and technical courses and credentialing of faculty teaching the program's courses.

At both two-and four-year degree levels, technical degree programs are often accredited by a professional organization. To achieve accreditation (desirable in terms of external credibility) programs have to meet the organization's standards and undergo periodic review.

At the secondary school level, there are usually state-approved curricula that set minimum course requirements for graduating. Vocational programs are also controlled at the state level, although schools have a great deal of flexibility in specific content. In nonvocational programs, instructional design, specific content, laboratory modules, and educational materials are often controlled at the school level and, in many situations, at the individual teacher level.

The State of ATE Program Improvement Efforts

To what degree have ATE *projects* succeeded in program improvement efforts? This is a legitimate question, considering that program improvement embodies the *Scientific and Advanced – Technology Act of 1992's* ultimate purpose of creating a world-class technical workforce. A review of several sources of information is presented below that focuses on the state of ATE's program improvement efforts and the degree these efforts have been successful.

- Surveys of ATE *projects* conducted by the WMU evaluation project (2000 and 2001 editions)[22]

[22] The 2000 Survey Report was a final version and the 2001 a draft version. In general, referenced data will be from the 2000 survey. When significant differences between 2000 and 2001 data are evident, this fact will be noted.

- Reports of site visits to selected *projects* conducted by the WMU evaluation project[23]
- A review of sample program course outlines and descriptions of improved programs [24]

These data sources are analyzed, summarized, and presented in the context of the nine key elements of ATE program improvement identified above (The surveys gathered data on three levels of program improvement—secondary, associate degree, and baccalaureate. In keeping with this approach, the information provided in this section will, to the extent feasible, report on the same three levels of effort.)

Revises or develops a technical educational program. The data reported by *projects* reveals that the vast majority of the improvement efforts are focused at the associate degree institutions (a reflection of Congressional and NSF-ATE intent reported above). Of the *projects* responding to the surveys, 93 percent reported efforts were at the associate degree level.[25] Of the 57 *projects* reporting improvement programs, 29 were exclusively at the associate degree level, while two were at the secondary level only. None of the reported *projects* focused only at the baccalaureate level. The remaining 26 activities were a combination, with all but one involving the associate degree level.

Three hundred seventy-one programs were reported as "developed/offered" by the 57 *projects*. The majority of reported programs were at a combination award level (197), 168 were exclusively associate level, 6 were at the secondary level, and none were at the baccalaureate level. These data are fairly consistent in the 2001 report.

Seven site visit reports deal with associate-degree college *projects* with a focus on program improvement as defined above. These programs cover a variety of disciplines and some have several award levels ranging from a limited and/or advanced-certificate to an associate degree. Data from review of program documentation were consistent with the data from the surveys and site visits, since all selected programs were at the associate degree level institutions.

Based on these data, it is clear ATE program improvement *projects* are developing or revising one or more specific technical program(s). For a variety of factors (e.g., previous

[23] Site visit reports are comprehensive documents created by members of the WMU evaluation project's visiting teams that did on-site reviews of ATE *projects* at 13 locations. These reports are limited in their distribution to preserve the anonymity of the sites visited. Therefore, no citations will be provided when referring to information contained in these reports.

[24] The sources of this review were program descriptions and catalog materials from selected *project* institutions (approximately 35 programs at 15 institutions).The limitations to this review are the limited scope of the review, the lack of a "before improvement" benchmark to measure change, and the brevity of course descriptions. In spite of these limitations, useful information on STEM integration in program improvement was gained. To preclude identification of specific projects, direct references will not be provided.

[25] The reported data on levels of program improvement can be misleading. Although 93 percent of the respondents were involved at the associate degree level, only half were exclusively at that level. The remaining 40 percent were at multiple levels of secondary-associate or associate-baccalaureate levels.

identified need, approval process, existing expertise, and faculty), *projects* show a distinct preference for program revision.

Reflects an integrated curriculum development and implementation process. Although the available data on how the *projects* developed and implemented their improved programs are limited, based on site visit report comments, it appears the *projects* approach the task in a structured manner. Most *projects* were in collaboration with other two-year colleges, and in many instances, the program improvement process was decentralized. Partners in these consortia-like arrangements were actually developing and implementing products, and in most cases, were responsible for program improvement efforts at their colleges. These distributive approaches to program improvement are in keeping with ATE's objective of impacting the greatest number of programs regionally or nationally. In terms of evaluation, the consortium work could not be directly reviewed and relied on the report of the *project's* focal point personnel.

Is an organized sequence of classes, laboratories, and work-based educational experiences. Those programs for which data were available presented a sequence of learning experiences that seemed logical and used active learning strategies.[26] Based on course descriptions, the technical course content makes extensive use of laboratory, field, and work-based learning/teaching strategies. The program outlines and course descriptions reflect an integration of knowledge and skill-building activities and an emphasis on applying the knowledge and skills throughout the curriculum. Most programs examined had a "capstone course" at the end of the program that required students to demonstrate an ability to integrate their knowledge and skills. However, the issue of a sequenced curriculum of building blocks of knowledge, skills, and competencies that led to qualification as a skilled technician was not directly investigated. For optimum learning, the sequencing of learning experience that reinforces and applies previous learning should be a basic approach in improved programs.[27]

Emphasizes STEM standards, communication skills, critical thinking, advanced technology courses, workplace competencies, equipment use, teamwork, and perseverance. The survey requested that respondents choose one specific program in one location and report on that program in some detail to minimize burden on the respondents. The *projects* reporting program improvement activities reported on the type of course development attributable to grant funding in their programs. These data were not broken down by educational level but displayed by content and action. Developing new courses and revising current courses were essentially tied in terms of numbers in 2000. In 2001, a notable increase in new courses was reported. Since developing new courses requires more time than revising an existing course, it seems reasonable that the 2001 increase in new courses can be attributed to *project* maturity. The content areas of new/revised courses consisted primarily of STEM, field-related (workforce based in nonfield settings), and technology topics. The topic areas also seem reasonable for course improvement in STEM programs.

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[26] An issue requiring more data and analysis is the degree students are required to and do follow the program sequence.

[27] ATE guidance to institutions seeking funding states "that all programs have a core of courses in science and mathematics to serve as prerequisites or co-requisites for specialized technology courses." *ATE Program Solicitation*, 1998, p. 3.

Site visit *projects* indicated that the major objective of course/materials development is strengthening science and mathematics as well as integrating advanced technology content. Use of industry workplace standards and competencies are universally reported as the bases for program improvement. Use of DACUMs,[28] industry standards (particularly in the information technology [IT] area), and meetings with advisory committees were the reported source of these standards. Some reports alluded to the inclusion of soft skills (e.g., teamwork, communications, critical thinking) in improved programs. Work-based learning, such as internships, is available in all programs but not required in all. One *project* stated that although preferred, mandatory internships were not possible due to limited positions in industry.

All the reviewed documentation indicated that degree programs require one or more core mathematics courses in their ATE program (One course is normally a minimum required in any associate degree program by regional accreditation associations). The content of these courses varied widely. Typical approaches to the core mathematics included those listed below:

- A transfer level statistics course for which an equivalent readiness of intermediate algebra is required[29]
- A transfer level plane trigonometry course for which an equivalent readiness of intermediate algebra is required
- Intermediate algebra or advanced/college algebra
- Both a trigonometry and algebra course
- Technical mathematics[30]

A review of the program documentation does not show any requirements for mathematics above statistics or college algebra. Based on these data, one can assume that the mathematics required in technical courses does not exceed the required curriculum level. Also, the mathematics required by associate degree technical programs (for which course descriptions were available) is generally below that in four-year programs, but is at an acceptable level for the competencies needed in the "skilled technician" workforce.[31] Catalogs and program displays do, however, caution students that higher-level mathematics course are advisable, if the student plans to transfer to a four-year program.

[28] DACUM (Developing A CUrriculuM) is a structured way of identifying worker duties and tasks via a group process using "expert workers" from industry. The process is often used in community colleges to determine standards for both new and revised program development. Some effort has been made to adapt DACUMS to predicting future technical education needs, but the lack of expert workers makes such use marginally effective.
[29] As used here "readiness" is the level of mathematics proficiency a student must demonstrate by either testing out of or passing an appropriate bridging course prior to enrolling in the specified curriculum course.
[30] Technical mathematics is a course designed for career programs that cover topics needed in technical applications. Topics range from arithmetic functions such as fractions and decimals to basic algebra, trigonometry, geometry, and statistics. These courses are normally not transferable to four-year programs.
[31] It should be noted that only one engineering technology program sequence was reviewed by site visits and in the document review. The mathematics literacy of technicians in these fields could be significantly higher than those discussed above.

Although quite variable in level and content, integrating the use of mathematics in technical offerings was apparent in many technical course descriptions. Reinforcement of mathematics skills via application throughout the curriculum seemed to be a fairly consistent.

In the area of science, the variation was considerably more than in mathematics. This is predictable because of the differing disciplines of the ATE-improved programs and the relevant science. In programs with life science disciplines, the science requirements were usually in the area of biology, and the technical components were heavily weighted toward use of scientific procedures and information. The same was true in environmental disciplines, although emerging environmental science courses were also evident. Chemistry and/or physics was also required in some programs, usually coupled with advanced/college algebra. Several program documents reflected no requirement for a general education course in science. In some of these cases, the use of science methodology was reflected in technical course descriptions. In reviewing technical course descriptions, the extensive use of "inquiry based laboratory and field based modules" was evident.

The one exception was in the Information Technology (IT) area. Here the science requirement was limited (or nonexistent) and the technical courses were primarily computer based. The nature of the IT discipline (using, networking, repairing, and programming computers) and the heavy use of industry-developed instructional materials designed for certification appeared to limit the traditional science requirements. The analytical thought process associated with science seemed to be reflected in some technical course descriptions; however, many appeared to be phrased in "learn to do" terminology.

A curriculum strong point seemed to be communications skills. General education courses were uniformly at the transfer level and included writing and oral presentation development. In all disciplines, many technical course descriptions contained a theme of students presenting analytical information in writing or orally. Based on catalog information, it was evident there was adequate emphasis on communication skills.

Several other items of interest in evaluating program improvement were distilled from the course descriptions:

1. There is an emphasis on critical thinking skills.
2. Working in teams is used in numerous courses in an effort to develop this skill.
3. Many programs have a capstone course that requires students to demonstrate the integrated use of knowledge and skills developed during the program.
4. Advanced technologies and use of modern equipment associated with a particular discipline are included in programs.
5. Programs use actual or simulated work-based educational experiences as part of their curriculum.
6. Students are expected to be active versus passive learners in their technical offerings.

The above discussion deals with programs leading to the associate degree. Documents and site visit reports also identify credit and noncredit certificate options for many of these programs. As a general rule, certificate programs include little or no general education.

However, the technical content is the same.[32] The intended audience for these courses includes "reverse transfer" students,[33] upgrading professionals, and students seeking employment skills in a minimum of time. Except for the students' who defer general education and take technical offerings only, these certificate offerings seem very appropriate. For those students with limited mathematics, science, and communications readiness, achieving the competencies expected from the technical offerings can present a challenge.

Of course, the unanswered question is "What is the impact of this effort on student learning?" Currently, there is no discernable data about the efficacy of the improvements being made. In general, these data will be difficult to obtain and verify independently, since collection methodologies are not in place at all *projects*. However, to fully address the impact of program improvement, more data are needed on the following:

- Pilot and field-testing of instructional materials. Except in one case where state-approved new curriculum requires pilot testing, there is no mention of the process of verification of the effectiveness of materials/programs in site visit reports, nor are plans to do so presented. In one report, the lack of such testing was cited as a potential weakness. No attempts or plans to gather longitudinal field-testing data were reported.
- Verification of industry standards. Based on survey data and site visits, there was evidence of the initial development and use of industry standards in program improvement *projects*. Many *projects* had not developed an industry-based verification process as these standards were integrated into courses/materials of the program. Nor was there evidence of a systematic way to update the standards except through program advisory comments. The exceptions were standards developed by the Information Technology (IT) industry and used as criteria for formal certification.
- Documentation of program materials. Generally, comments in site visit reports indicate limited and incomplete documentation of newly developed or revised courses/modules. Since many of the program improvement *projects* are consortia or partnership based, the lack of adequate documentation may have dramatically reduced use of materials by other collaborating programs as well as verification of their effectiveness. Lack of or poor documentations would also constrain dissemination of the ATE product.
- Pedagogical issues. Use of appropriate pedagogy is not generally addressed, but the site visit comments that do appear express concerns that this is not a strong aspect of program improvement at the visited *projects*. At issue is whether *projects* are infusing a variety of teaching styles required by a diverse student population.[34]
- Extent that science and mathematics has been enhanced. From both the survey and site visit reports, it is clear that *projects* are attempting to increase the amount and rigor of science and mathematics in improved technical programs, both in core or general education as well as technical courses[35]. However, neither source addresses the degree to which these efforts are successful.

[32] This holds true for both credit and noncredit continuing education offerings.
[33] Students who already possess a college degree or have had substantial college-level general education.
[34] *ATE Program Solicitation*, 2000, p. 8.
[35] *ATE Program Solicitation*, 2000, p. 17.

Overall, the program improvement process was clearly focused on creating curricula that are more rigorous in STEM and communication skills. Programs were designed around workforce competencies and reflected use of appropriate equipment. Curriculum design featured application of mathematics, science, and communication skills. Programs required students to work in teams and created scenarios that required students to solve problems by using critical thinking and to provide their rationale for the problem solution proposed. These problem-solving aspects of the programs are generally based on use of research skills, including those associated with the Internet. As mentioned above, it should be noted that verification of the program's content is constrained by lack of course documentation. The main issue, however, is not the intent or design of the improved programs, but how effective these efforts are in producing skilled technicians. For example, data indicate there is a minimum use of business and industry to confirm standards or evaluate the results of a curriculum. There is no evidence of extensive field-testing of programs, and *projects* do not have plans for a longitudinal study of completers' performance.

Is conducted and available to students over a significant period of time. Based on information gathered at site visits and from program documents, programs range from less than a year to approximately two years. The two-year programs are both secondary and associate degree based. Certificates at community colleges can be earned in one to three semesters. No examples of four-year programs were available, but based on an assumption such programs would include transfer from an associate degree program, it is anticipated that they would consist of two or more years of study.

Prepares diverse student populations with the knowledge and skills required for employment in a specific advanced-technological field. As defined, one objective of ATE program improvement is increased diversity. Recruitment of diverse students is, therefore, an expected activity if funded *projects* are to make a significant impact on increasing the number of underrepresented populations[36] in the technical workforce. Based on survey and site visit data, the dedication by ATE programs to recruiting is variable, ranging from none to formalized plans and targeted activities. At secondary schools, recruitment appears to be focused on middle school students with the objective of channeling them into technical offerings. The recruitment effort focus of associate level programs is both outside and inside the institution. Recruitment outside the institution appears to be more of an institution-wide effort and involves ATE *projects* in collaboration with special student services/success units. This associate degree institution-wide approach seems appropriate, since it focuses greater resources on the issue of recruitment. ATE funds can be used more effectively to enhance the institutional effort than to create a separate effort. Baccalaureate recruiting is generally focused outside the institution. Overall, the data did not provide a uniformly clear focus by *projects* on increasing underrepresented population participation in ATE-funded programs. Nor did these data reflect the degree of success, except for anecdotal comments, such as "increased female sign-up," "Hard to assess," "Excellent," and "No response."

[36] *Underrepresented populations* as used here refer to the proportional representation of categories of workers in a particular occupation in relation to the general population. This includes race, ethnicity, and gender.

However, diversity data were reported in the 2000 and 2001 surveys for both projects and centers. The data for 2001 are presented below.[37]

STUDENT DESCRIPTOR	SECONDARY LEVEL (%)	ASSOCIATE LEVEL (%)	BACCALAUREATE LEVEL (%)
Female	**20**	**29**	**26**
Minority	**52**	**40**	**52**
White	**43**	**42**	**27**
Disabilities	**7**	**2**	**8**

Although these data do not shed much light on the issue of ATE *projects* actually "creating a more diverse workforce," the number of minorities in programs seems to indicate that there is significant diversity based on race and ethnicity.[38] Based on the author's observations at ATE sites, the reported female participation appears low.

As discussed above, use of appropriate pedagogy is not generally addressed in detail. At issue is whether *projects* are infusing a variety of teaching styles required by a diverse student population.[39]

Leads students to an appropriate degree, certification, or occupational competency point. The concentration of program improvement program award levels is, as expected, at the associate degree institution. The program award/educational level matrix (programs of the n programs per degree level that offer degrees or certificates [e.g., 34/36 offer a degree at the associate level) for 2000 and 2001 is reflected below:

AWARD LEVEL	SECONDARY (n=18)	ASSOCIATE (n=36)	BACCALAUREATE (n=5)
DEGREE	5 ***6***	34 ***34***	5 ***3***
CERTIFICATE	7 ***12***	21 ***21***	2 ***0***

Note: Nonitalicized numbers are 2000 data, ***bolded italicized numbers*** *2001 data.*

The above distribution raises a critical question in the mind of the author. How can secondary schools grant a degree? The assumption offered is that the secondary school *projects* are in collaboration with a degree-granting institution (most likely a community college), and the award is made at the college level, not the secondary level. The reported data also reflect the award of certificates at the baccalaureate level in 2000 data, which again seems interesting, since it is not normal in these institutions to do so, except in non-credit continuing education offerings. Perhaps future survey instructions might require more specific guidance on how these data are to be reported.

[37] The total percentages of minorities plus whites would be expected to equal 100 percent. Obviously, in reporting data, *projects* did not ensure their data did so; thus, the totals do not reach 100 percent. Additionally, in future surveys a benchmark of "prior to ATE" would be useful in judging change in diversity enrollments.
[38] The distributions reported may be historical for the institutions, may reflect the mix of the area's population or, since they are an aggregate, may range widely for each reporting institution.
[39] *ATE Program Solicitation*, 2000, p. 8.

Based on the survey data, the site visit reports, and reviewed documentation, all the reported programs appeared to provide appropriate credentialing. The reported articulation agreements and the numbers of students "continuing their education" clearly indicate there is a demand for higher degrees in the advanced technology field (Data presented below indicate approximately one-third of program completers continue their education).

Provides industry with an increased pool of competent skilled technicians. Based on survey results, the WMU evaluation project's Survey Status Report concludes, "Large numbers of students are being impacted by the reported improved programs." This conclusion is based, in part, on data reported on new/improved course enrollments that show average enrollments of 76 at the secondary level and 1,075 at the associate level in 2000. In the 2001 survey, these numbers ballooned to 700 secondary and 2,300 associate degree enrollees. Based on how the item in the survey was phrased, the reported data would not necessarily reflect technical program majors. *Projects* report unduplicated head counts of students taking one or more improved courses regardless of major. Additionally, these 2001 reported average enrollments were significantly skewed to the high side by reported data at the secondary level of 2,000 and 5,000 enrollees in 2 secondary programs and 1 center reporting an enrollment of 70,000.[40] Different statistical techniques could have been employed to reduce the bias created by the several exceptionally high reported enrollments.[41]

The survey did ask for data on program enrollments and completers for the special reported programs.[42] These data are directly tied to the number of students potentially moving into the skilled technician workforce. Again, it should be noted these data are based on a single program per *project* selected by the *project* leaders and not a structured or controlled sample. The numbers presented over the 12-month periods follow (none reported at the four-year level):

- Secondary:
  - 2000 – An average of 173 enrollees with 125 completers
  - 2001 – An average of 98 enrollees with 40 completers
- Associate:
  - 2000 – An average of 94 enrollees with 43 completers;
  - 2001 – An average of 160 enrollees with 58 completers

2000 survey data concerning program completers at the associate degree level indicate approximately 75 percent of the completers entered the workforce and 33 percent were

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[40] *Comparison of the 2000 and 2001 Survey Findings*, The Evaluation Center, June 2001, p. 9. Draft excerpt from *Survey 2001: The Status of ATE Projects and Centers.*

[41] A more sound statistical approach would have been to exclude the reported student populations that fell significantly outside the nominal range from the reported averages. Another approach might have been to include the median enrollments as well as the average to reveal the variation between the two measures of central tendency.

[42] It should be noted that these data are based on a single program per project selected by the project leaders and are not a structured or controlled sample. As a result, the reported averages may or may not be typical of all programs.

pursuing higher education.[43] The 2001 data reflect a decrease in completers entering technical positions (46%). This reduction of completers entering the workforce was not the result of greater numbers of "continuing education," which remained around 30 percent for both years. Whether the drop in the proportion of students placed in technician positions was due to the recent economic downturn in the technology sector or another factor (e.g., more students in the first year of a 2-year degree program in 2001 than in 2000) remains to be determined. Additionally, the data swings may be based on the lack of data at the *project* level. Based on the author's experience, tracking of program graduates is not a universally high priority at community colleges.

The above data indicate a growth in associate degree programs with some drop-off in secondary programs. With the increasing ATE emphasis on associate-degree-based programs, this change seems reasonable. However, based on the reported increased secondary course enrollment noted above (624 more in 2001 than 2000), the various data elements dealing with secondary enrollment/completion numbers are hard to reconcile. Refinement in how these data are gathered/displayed to distinguish secondary students enrolled in a technology course(s) versus those in a vocational/technical program would provide a clearer picture of ATE enrollments.

Based on site visit reports, the production of skilled workers from ATE improved programs is currently limited. Classes visited were small, and larger ones often included nonmajors, which could indicate that institutionalization is occurring. For example, one site reported 250 program enrollees, but in reality the number of majors was 13. The remaining students were in various programs and taking the IT course as a general science option. Additionally, multiple majors often required common courses, creating a larger course enrollment but with small enrollments in the several program options. However, the enrollment trends in ATE programs generally were reported to be increasing, and at some locations demand was exceeding available program seats. Particularly in the IT field, growth was constrained by lack of qualified instructors. Expanding instructor resources by using industry technicians was reported as a major focus in many of these *projects*.

Increases in completers can be expected as the ATE program matures. Data from the 2001 survey indicate that the enrollments and completers in selected associate degree programs are higher than those drawn from the 2000 survey (average enrollment 160, average completers 58 per reported program). The 2001 program completion data show a significant increase and indicate that ATE is having a growing positive impact on the U.S.'s workforce. Of course, in consortium arrangements, there are multiple production points, and total production for the *project* is larger than any single program. Also, no data are available on production from credit and noncredit certificate programs. It is probably safe to assume the number of completers from these programs is similar to credit programs and add to workforce improvement, especially by retaining existing technicians.

The ATE staff, with some assistance from the WMU evaluation project, has tried to use the survey enrollment and completion statistics to extrapolate total ATE associate degree

[43] Workforce versus education are not mutually exclusive categories, and students can be in both categories. Hence, the total can exceed 100 percent.

enrollment data. The approach was to multiply the "average number of students taking at least one ATE-impacted course in the past 12 months" (2,304) by the number of "reporting *projects*" (47) to yield an "impact estimate". As a result, the staff estimated 108,000 associate degree program enrollees (The WMU evaluation project also provided median numbers [e.g., median for associate degree program enrollees was 150].). Even if the extrapolated numbers were accepted, the impact on the U.S. technical workforce would be small.[44]

Expansion of ATE's impact on the technical workforce will require a significant effort to disseminate curriculum products from the "model instructional programs." ATE is addressing this with special dissemination grants for dissemination focal points and directing special efforts to develop regional centers focused on upgrading critical technical programs in fields such as manufacturing and information technology.[45] Grants in these areas should assist the spread of improved and new course materials to additional technical programs. To measure the impact on the workforce, it will be necessary for ATE to develop and implement methodology that provides empirical data on the spread of improved technical education via dissemination and regional consortiums.[46]

Is structured to obtain maximum articulation of educational experiences. Another aspect of program improvement reported in the WMU evaluation project's survey is credit transferability between institutions. This is a significant issue in technical education, since historically there been a resistance by institutions to accept credits earned in technical courses as part of degree programs at a higher educational level. The articulation of student "learning experiences"[47] between institutions is a major focus of the ATE program as it pertains to workforce development. The reported data reflect that transfers between like-level institutions are more common than between differing levels. However, the transfer between associate degree and four-year programs is also a strong component, with all but three *projects* reporting some degree of transferability. It is clear that there is a concerted effort to achieve program articulation, particularly at the associate/associate and associate/baccalaureate degree levels.[48]

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[44] Based on current Bureau of Labor Statistics (http://stats.bls.gov/), there are 33 million employees in the U.S. workforce with some college, but less than a bachelor's degree (10.7 million possess an associates degree). Although no statistical data identifies "technicians," it appears safe to assume that a significant number of the 33 million are in skilled advanced technology jobs. If this assumption is accurate, then the challenge of upgrading these technicians and producing more cutting-edge technicians is an immense undertaking.

[45] *ATE Year 2000 Program Solicitation*, p. 10 & 13.

[46] Current data gathering by the WMU evaluation project is not structured to obtain global statistics or impact information for materials disseminated by projects and centers. Revised protocols would be required to obtain these data.

[47] Transfer of learning experience (versus academic credits), although not widespread, does afford the potential for more articulated transfers. However, academic credit remains the "coin of the realm" for the vast majority of degrees.

[48] Historically, community college students have been able to transfer their lower division (freshman and sophomore level) undergraduate general education credits to baccalaureate programs. Most states mandate such transfer for publicly funded state institutions. On the other hand, technical credit transfer is normally an institution-to-institution negotiated agreement for individual courses (and sometimes for individual students). Even between same level institutions, general education credit transfer is more common than transfer of technical credit. The issue is generally the commonality of technical content. Advanced standing in associate degree programs based on secondary coursework does occur based on individual institution to institution agreements but is not, in the author's experience, widespread.

Site visit reports confirm the emphasis on associate to baccalaureate program articulation. All reported associate degree *projects* involved in program improvement had achieving and maintaining articulation with four-year programs as a major objective. Comments in the reports indicate a high degree of success by *projects* in this effort. At one location, a major state university actually developed an undergraduate and a graduate program sequence to accommodate graduates from associate degree institutions using ATE-developed programs.

The amount of credit transfer varies from program to program and is influenced primarily by the courses in the associate program. The positive impact of the increased rigor of ATE programs is evident once programs are "improved" by the number of programs negotiating new or revised articulation agreements.

Most associate degree programs are linked to secondary school improvement strategies focused on preparing high school students for community college programs in specific technical disciplines. The site visit reports indicate only one case where this relationship resulted in advanced standing of secondary students in the associate degree program. This an area where greater emphasis may be needed if secondary school vocational/technical students are to be encourage to continue their education.

Summary

Basically, the program improvement *projects* are clearly meeting the developmental aspects of the ATE program. Overall, the *projects* involved in program improvement are oriented to improvement of STEM both in their programs, and in the case of associate-degree programs, in feeder secondary programs. The improved programs reflect use of mathematics, science, and communications across the technical curriculum component. Use of standards to determine student competencies is universal; and when the work-based standards are not available, programs work with business and industry to identify them. The use of work-based education as part of the curriculum is also standard, but is not always a requirement. *Projects* integrate developing "soft skills" such as teamwork and critical thinking into their programs. The improved programs provide certification or award a degree where appropriate. At the associate level, there are usually multiple educational tracks to meet the needs of students with a variety of backgrounds and goals. Articulation of transfer of credits or prior learning experiences between community colleges and their four-year counterparts is the norm. However, there is very limited articulation involving granting advanced standing of students between secondary and community college programs.

The issue to be addressed by the ATE program is not the development of the programs, but the lack of data on outcomes. Although some outcomes data for programs are gathered via surveys, these data are incomplete. Data on performance by program completers (either on the job or in continuing educations) are not routinely gathered or analyzed, nor are plans to do so evident. Additionally, the absence of formalized pilot and field-testing involving business and industry constrains verification of program effectiveness and revision to meet the original or new program/course objectives. Incomplete documentation of courses limits dissemination and adaptation by other programs. Approaches to reaching a diverse student population via appropriate pedagogy are not documented in curriculum materials, and the effective use of these approaches is unknown. ATE will have to address these deficiencies before the success of the program improvement effort can be fully evaluated.

Recommendations

Based on the data and the conclusions presented above, the following recommendations are provided for NSF-ATE and ATE-funded *projects* engaged in program improvement:

Recommendations for ATE. NSF-ATE program managers should consider the following recommendations (Note: The rationale for the recommendation is presented below each recommendation and is based on the data presented in the paper.):

1. Continue the increased emphasis on disseminating products that are developed by ATE *projects* and develop a protocol for measuring the impact of these efforts, since materials development is integral to program improvement

   A large number of ATE-supported materials are being developed and implemented by *projects* involved in program improvement. However, the impact of these materials in preparing skilled technicians is small when compared with the size of the U.S. workforce. To achieve a significant impact, more technical education programs need to adapt these materials to their program needs. ATE should consider expanding support of dissemination strategies, including providing guidance on approaches to and funding for clearinghouse-type efforts. *Projects* disseminating materials should be required to provide data on the results of their efforts as a requirement of accepting funding.

2. Place greater emphasis on pilot and field-testing of the materials developed for the programs by the *projects* and encourage the involvement of business and industry in these activities

   Projects are producing significant quantities of enhanced materials; however, there is minimal verification of these products by the user—business/industry. To ensure materials are meeting their ultimate objective of educating skilled technicians for the workforce, those employing the program completers need to be part of the pilot/field-testing process.

3. Define minimum standards for documenting materials and require *projects* to meet or exceed these standards

   Based on site visit reports, there is minimal detailed documentation of improved instructional products. This limits the dissemination of these materials to other potential users and constrains the expanded impact of producing more advanced technicians.

4. Encourage *projects* to identify, document, and use advanced pedagogical approaches to meet the learning needs of a diverse population

With increased diversity in the U.S. population as reflected in ATE program enrollments, instruction should be provided in ways that meet the varied needs of the population. Data from reports indicate that the pedagogical approaches to ensuring learning in diverse populations are, at a minimum, not documented and may not be given high priority by *projects*.

5. Fund *projects* that develop replicable strategies for increasing articulation between secondary schools and those associate degree colleges that provide secondary students with advanced college standing

   There is a strong emphasis by *projects* on articulation at the degree level, but limited emphasis on granting advanced standing for secondary students in technical programs. Providing such advanced standing could act to encourage students to continue their studies in advanced technological disciplines.

6. Define the protocol for routinely gathering program improvement data (including those in underrepresented populations and resulting from product dissemination) and analyze these data in relation to the U.S.'s requirements for skilled technicians

   As discussed, there is no source of verifiable outcomes data for the ATE program. Without these data, the efficacy of the program can be called into question. Although there is often a bias against gathering statistical data, it is essential to "count the beans" if ATE's staff is to answer questions about production and workforce impact.

7. Develop and fund longitudinal evaluation of the performance of completers of improved programs

   Under the current system of funding, the impact of ATE-educated technicians in the workplace is not, if measured, reported since there is no funding or requirement for longitudinal tracking of program completers. A segment of the ongoing evaluation of the ATE program should be to develop and conduct a longitudinal impact study.

8. Continue to fund external evaluations of the ATE program, including site visits, to determine an independent measure of the impact of efforts to increase skilled technicians. As part of the evaluation effort, data reporting methodology should be refined and standardized to increase the usefulness of these data.

   The current evaluation process of ATE *projects* is producing the only comprehensive data on the impact of the program. As with any complex effort, instruments such as the survey will require refinement. Also, issues about production and impact data need to be addressed through the evaluation effort. Continuation of an independent external evaluation process is prudent.

Recommendations for ATE projects. The following recommendations are provided for ATE-funded *projects* in program improvement:

1. Verify the effectiveness of their improved programs

2. Involve business and industry throughout the program development and implementation phase of the *project*

3. Encourage work between community-college-based *projects* and secondary schools to create advance standing transfer agreements for secondary students satisfactorily completing a block of secondary level instruction in the appropriate discipline

4. Create materials and course documentation that can be used by others to replicate or adapt program improvement course/components

5. Aggressively encourage institutions with similar human resources development needs to adapt and use materials developed as part of the program improvement project, and mentor this process

6. Routinely collect and analyze outcomes data

7. Gather and analyze data on the performance of program completers

Strategies for Evaluation

The items below should be considered for *project* improvement evaluation plans. They also can serve to assist organizations or individuals developing proposals for ATE funding in structuring *project* activities.

1. Review workforce and associated standards in relation to outcome competencies of the program improvement *project*

2. Determine the degree of improvement and effectiveness of STEM instruction

3. Evaluate the integration level of STEM, communications, and the development of teamwork and critical thinking skills throughout the curriculum

4. Compare equipment used in the program to that used by technicians in industry

5. Determine effectiveness of teaching/learning strategies used to meet the needs of a diverse student population

6. Gather and analyze program pilot and field-test data

7. Gather and analyze outcomes data for all *project* locations

8. Determine employer satisfaction with program completers

9. Collect and analyze program effectiveness data such as retention and placement

10. Review program documentation for adequacy in dissemination, replication, and adaptation efforts

11. Create a methodology for tracking completers and their effectiveness as part of a world class workforce